



CLEMSON UNIVERSITY

RESTORATION INSTITUTE

Offshore Wind Power Development and its Challenges

Workshop for Offshore Wind Energy Development

Charleston, SC

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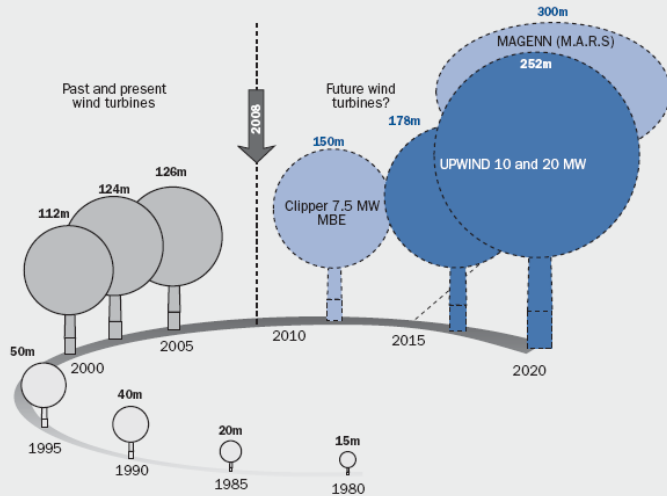
Challenges to US Offshore Wind Market

- Cost of Energy Delivered
 - New technology innovation
 - Streamline permitting
 - Critical mass of industry
- Long-term public policy
- Insurance
- Experience
 - Hardware
 - Workforce development
- First to take the 'plunge'
- Environmentally responsible
- Efficient distribution of energy





Turbine technology continues to evolve



Source Garrad Hassan

Land based Project: ~\$2M/MW

- Turbine 75%
- BOP 25%

Offshore Project: ~\$4-5M/MW

- Turbine 45%
- BOP 55%

GE 1.5 MW



Siemens 2.3 MW



Vestas 3.0 MW



RePower 5 MW

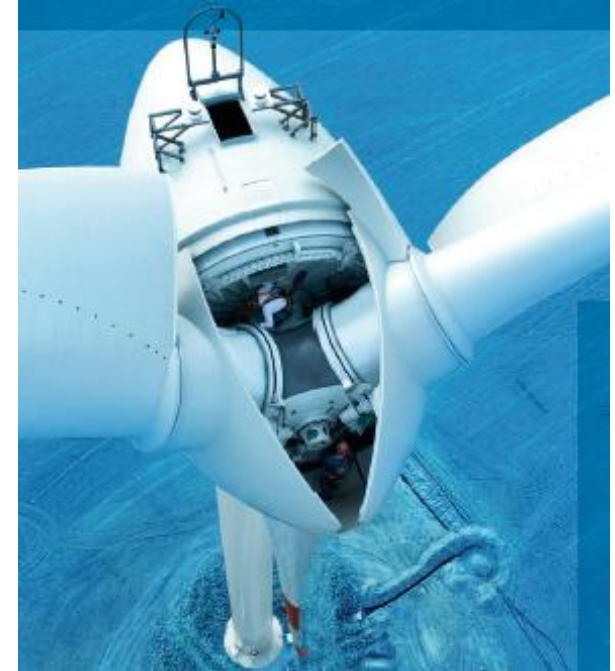
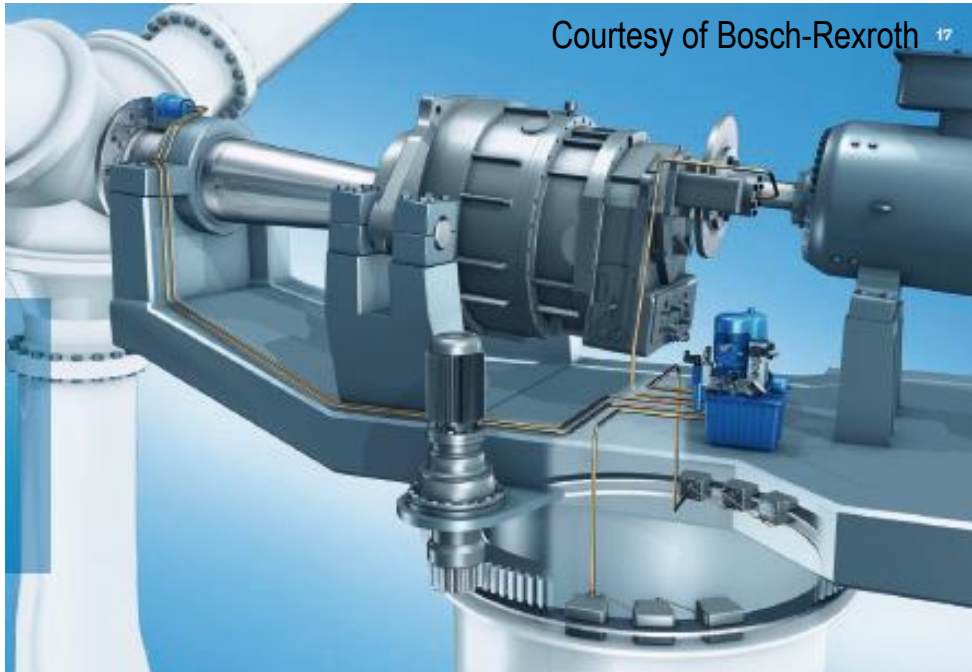


Enercon 7 MW





Increased reliability and reduce cost of energy



Key Issues:

- Gear Boxes
- Bearings
- Materials
- Constructability
- Work force development
- Grid compatibility
- Market compatibility

Challenges:

- Advanced materials
- Predictive failure modeling
- Energy storage
- Sensors
- Gear design
- Construction methodology
- Smart grid integration



CU Wind Turbine Drivetrain Testing Facility



US DOE EERE: DE-FOA-000012 : \$98M Project

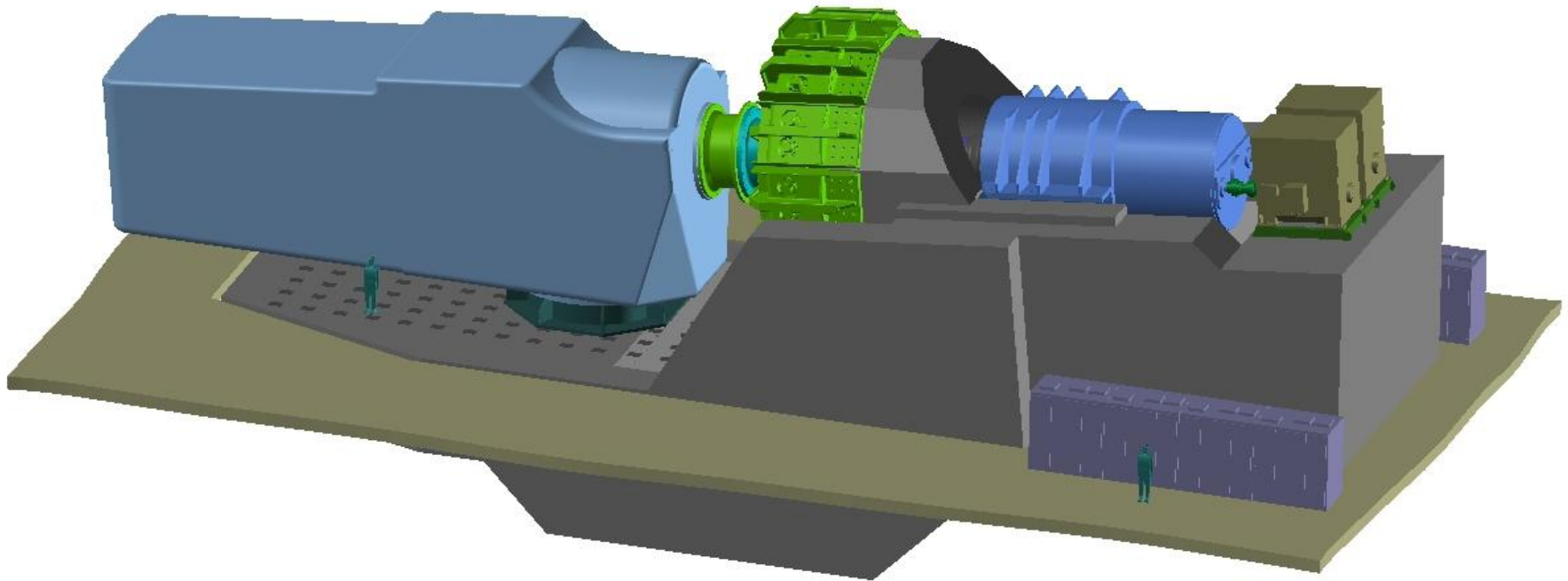
▪\$45M US DOE EERE, \$53M Matching Funds

Primary Mission: Provide (1) **High Value**, (2) **High Quality** and (3) **Cost Competitive** testing services , with high integrity and respect for the 'end users' intellectual property.

Secondary Mission: Establish long term partnerships with industry for work force development, research and education.

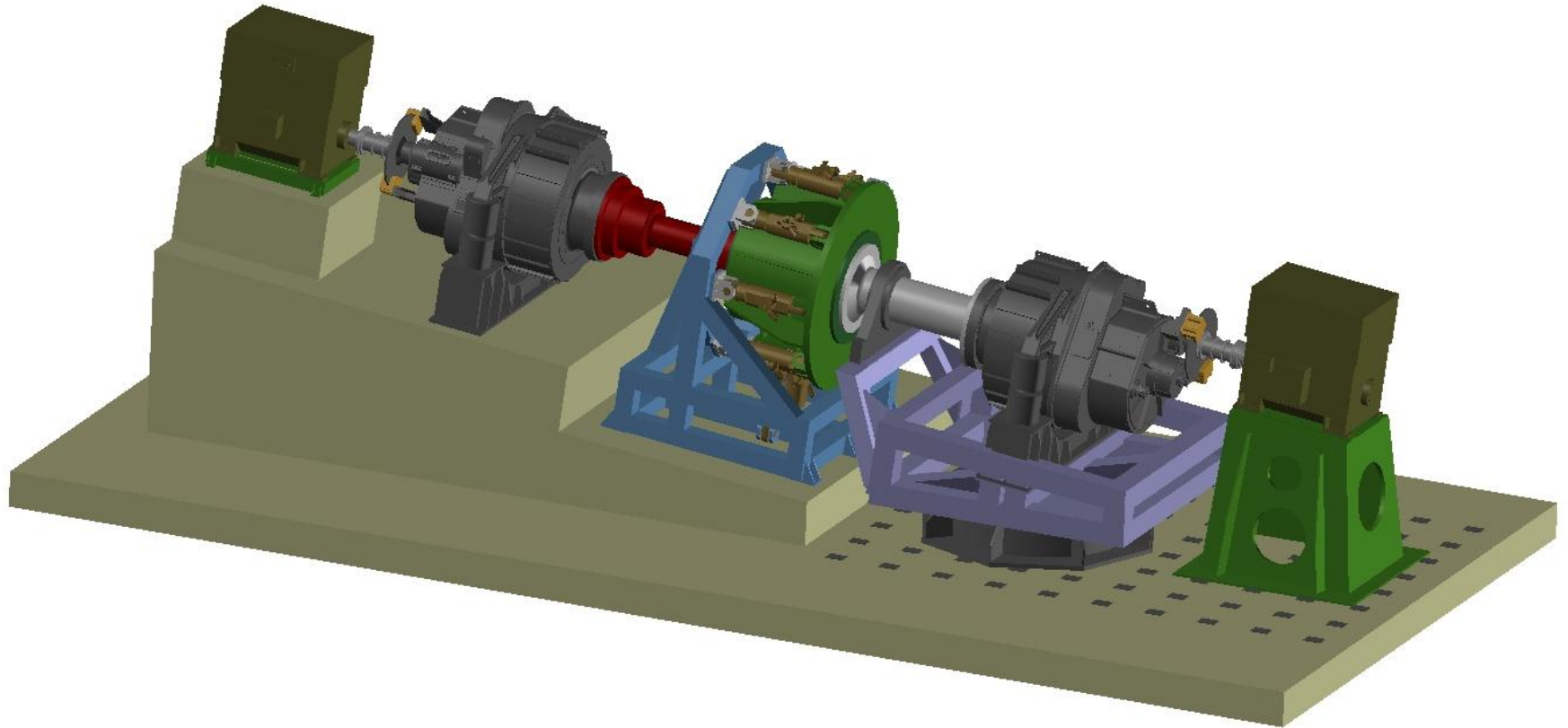


Test Rig #1: 15 MW with Dynamic Load Applicator



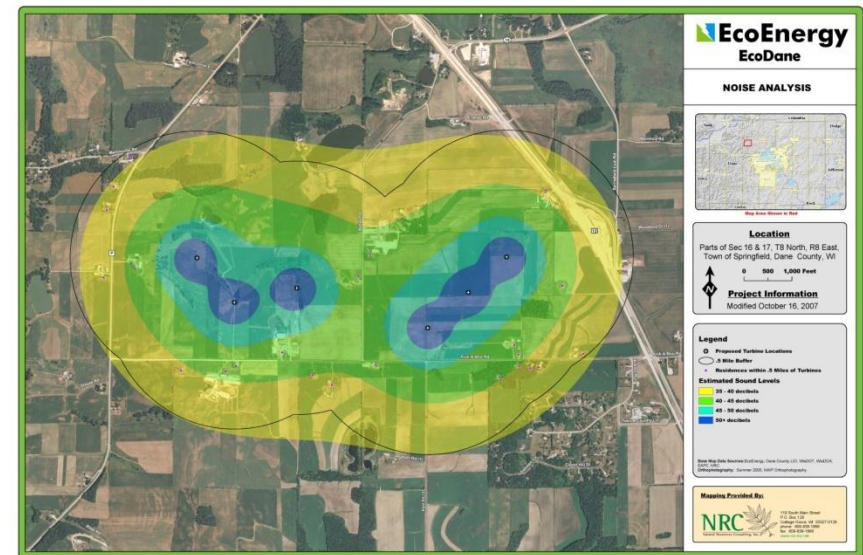
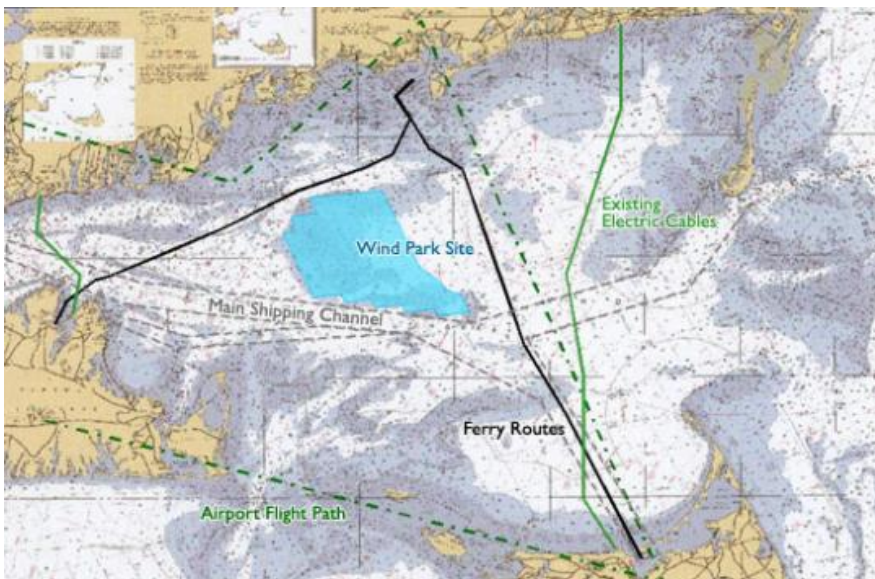
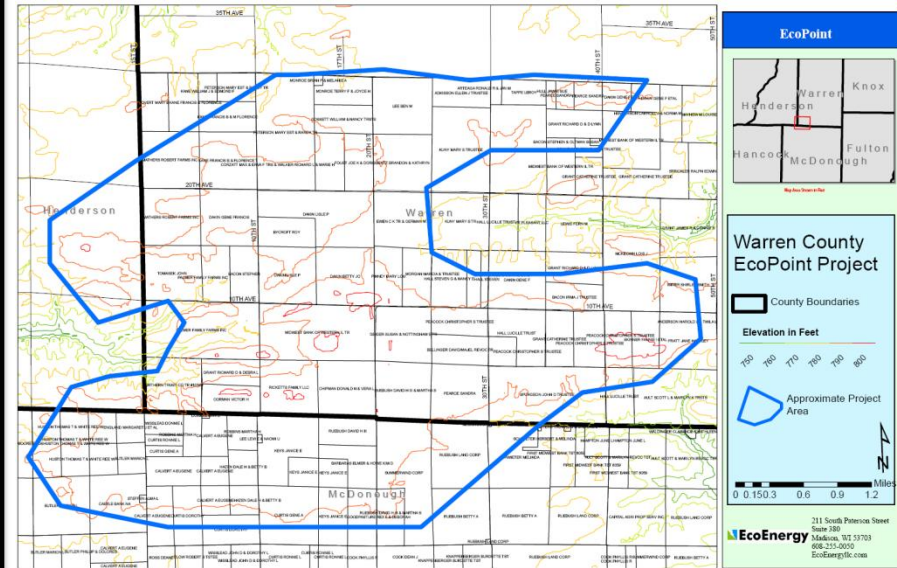
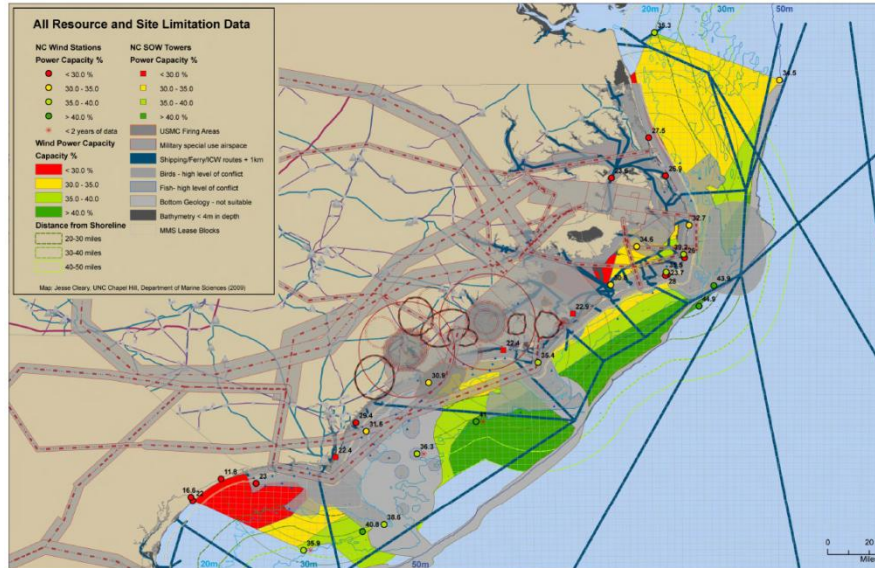


Test Rig #1: 7.5 MW with Static Load Applicator





Compare Offshore and Land-based Wind Farm Development



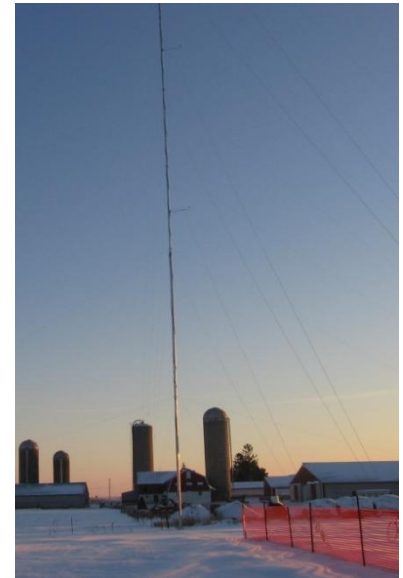
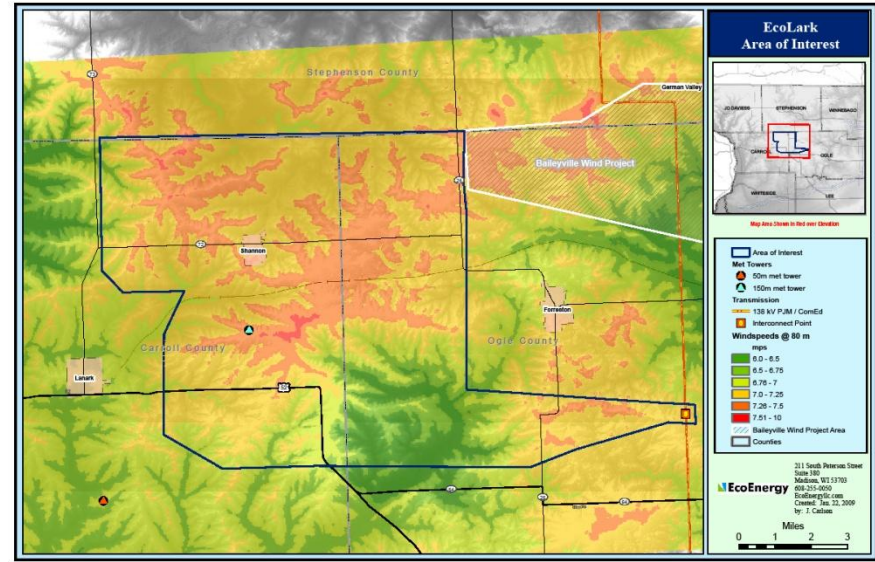
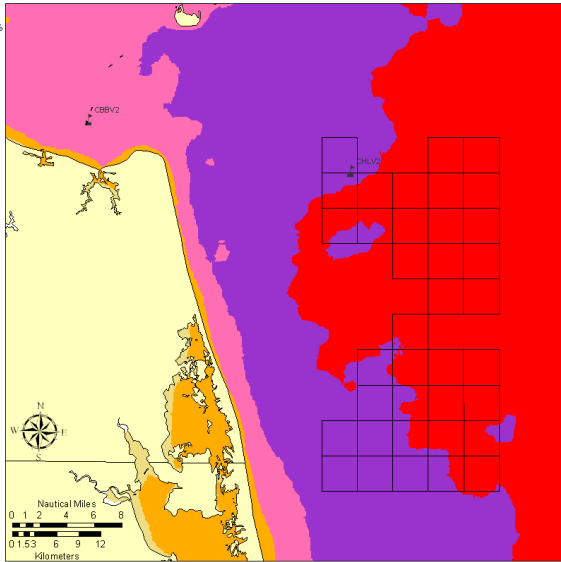


Wind analysis of site

Legend

- WMS Lease Blocks - no exclusion >50%
- Land
- Boats
- Wind Class at 50m - to 50nm
- Wind Class

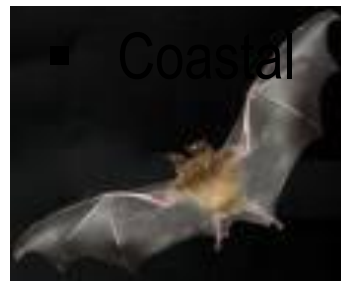
Wind Class
1
2
3
4
5
6
7





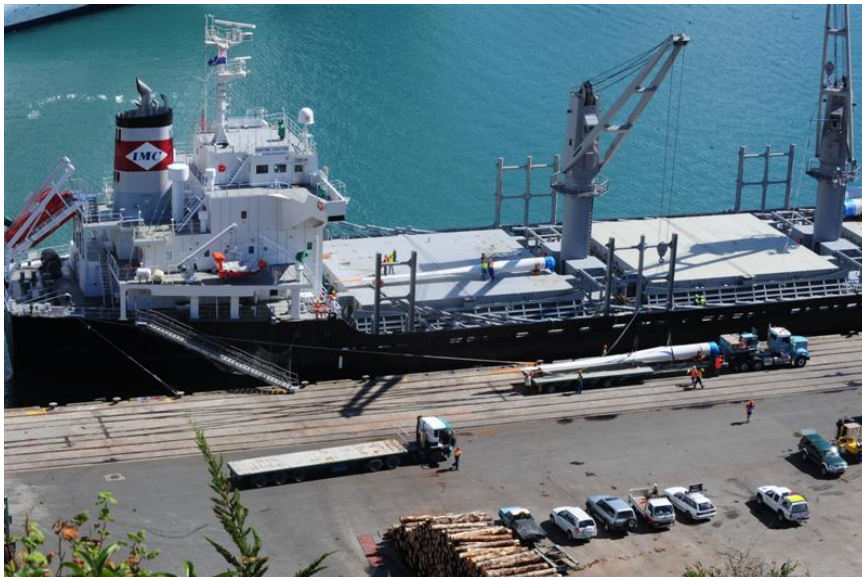
Studies of the proposed site

- Aviary
- Bat
- Archeological
- Wetlands
- FAA
- Lighting Plan
- Microwave Beam Paths
- Road surveys
- Noise
- DOD
- Transmission



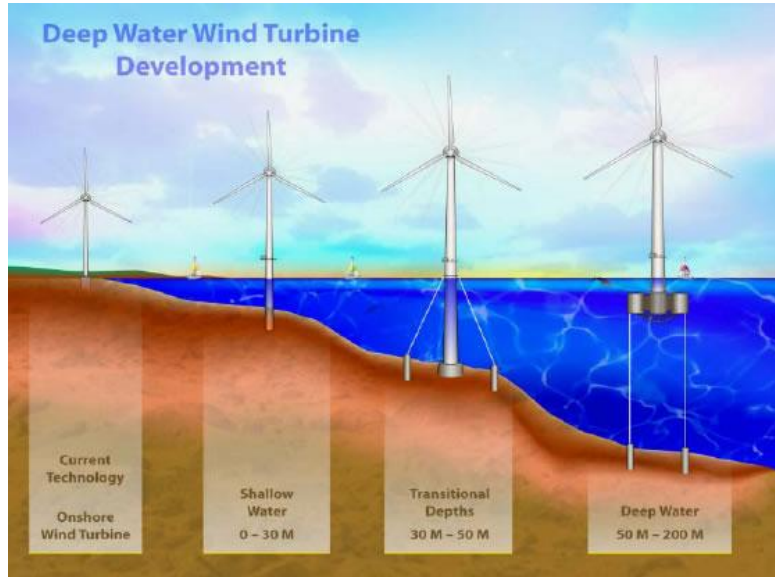


Access to the site





Foundations installed





Key components moved to site





Install electrical infrastructure





Erect the turbines





Final product





Offshore Wind Turbine Manufacturing and Services Cluster

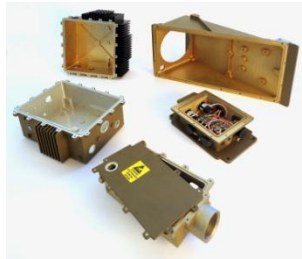
Tower Fabrication



Cable Laying



Turbine Assembly



Component Manufacturing

South Carolina serves as the
manufacturing hub



Logistics



Blade Manufacturing



Construction



Foundation Fabrication



Manufacturing Cluster to service markets

